Chapter 7
Ductile Iron Pipe and Steel Pipe for Other Applications

7-1. General

a. Ductile iron pipe (DIP). Ductile iron pipe has replaced cast iron pipe in use and application. Ductile iron pipe is used under levees and for water mains and other installations where fluids are carried under pressure. It is also suitable for pressure sewers and for gravity sewers where watertightness is essential. It can resist relatively high internal and external pressures and corrosion in most soils. However, it is subject to corrosion caused by acids, highly septic sewage, and acid soils. It is generally available in sizes up to about 1,625 mm (64 in.). Flexible bolted joints are required under levees and in other locations where differential settlement is anticipated.

b. Steel pipe. Steel pipe should be used for discharge lines from pumping stations for flood protection work. In general, these pipes should be carried over rather than through the levee. Steel pipe should be designed in accordance with American Water Works Association (AWWA) M11 (AWWA 1985).

7-2. Materials

The standards listed in Table 7-1 may be referenced by designers using these materials.

7-3. Installation

Ductile iron pipe is normally installed in the trench condition. When using first-class beddings and a backfill compacted to 90 percent standard proctor, American Association of State Highway and Transporation Officials (AASHTO) T-99 or better, the values shown below apply. When other beddings and backfill conditions are used, refer to American Society for Testing and Materials (ASTM) A 746 for loading constants.

7-4. Loadings

Because ductile iron pipe is normally installed only in the trench condition, this is the only loading condition discussed in this chapter.

7-5. Methods of Analysis

Equation 7-1 for bending stress and Equation 7-2 for deflection are used to calculate the maximum trench load the pipe can withstand for earth and live loads in terms of the vertical field stress as N/m^2 (psi). It is recommended that a Type 4 (ASTM A 746) bedding be used and that actual pipe beddings and backfills be verified by a geotechnical engineer.

Table 7-1
Materials for Ductile Iron and Steel Pipe

Materials	Standard	Notes
Ductile Iron Pipe	ASTM A 746 - Ductile Iron Sewer Pipe	This standard covers ductile iron pipe with push-on joints. Loading covered for this pipe is a trench condition for cement-mortar-lined or asphaltic-lined pipe.
	AWWA C150/A21.50 American National Standard for the Thickness Design of Ductile-Iron Pipe	---
	AWWA C110/A21.10, American National Standard for Ductile-Iron and Gray-Iron Fittings 3 in. through 48 in. (75 mm thru 1220 mm for Water and Other Liquids	There is a compatible standard from American Society of Mechanical Engineers (ASME).
	AWWA C115/A21.15, American National Standard for Flanged Ductile-Iron Pipe with Threaded Flanges	There is a compatible standard from ASME.
Steel Pipe	AISI 1989, Welded Steel Pipe-Steel Plate Engineering Data-Vol. 3	---

$$P_v = \frac{f}{3\left(\frac{D^2}{t^2} - \frac{D}{t}\right)\left\{K_b - \frac{K_x}{\frac{8\frac{E}{E'}}{\left(\frac{D}{t} - 1\right)^3} + 0.732}\right\}} \quad (7\text{-}1)$$

where (for bedding Type 4 per ASTM A 746 similar to first-class bedding)

P_v = trench load, earth plus live, N/m^2 (psi)

f = design maximum stress, 330 N/m^2 (48,000 psi)

D = outside diameter, mm (in.)

t = net pipe thickness, mm (in.)

K_b = bending moment coefficient, 0.157

K_x = deflection coefficient, 0.096

E = modulus of elasticity, 165,475 MPa (24,000,000 psi)

E' = modulus of soil reaction, 3.5 MPa (500 psi)

$$P_v = \left(\frac{\Delta X/D}{12K_x}\right)\left(\frac{8E}{\left(\frac{D}{t_m} - 1\right)^3} + 0.732\ E'\right) \quad (7\text{-}2)$$

where

t_m = minimum manufacturing thickness, t + 2 mm, t + 0.08 in

$\Delta X/D$ = design deflection/diameter, 0.03 for concrete lined, 0.05 for asphaltic or plastic lined

7-6. Joints

Use the materials referenced above for the type of joint used. The two available types are push-on and flanged. Joints can be restrained for thrust forces by using thrust blocks, restrained joints, or tie rods. Thrust restraint is required at tees, closed valves, reducers, dead ends, or wyes.

7-7. Camber

Where considerable foundation settlement is likely to occur, camber should be used to ensure positive drainage and to accommodate the extension of the pipe due to settlement.